

T.A. 7
CC
CER 59-11

COPY 2

MAR 12 '74

FOOTHILLS READING ROOM

EVALUATION OF THE PERFORMANCE OF
THE GULTON ULTRASONIC, GENTILE TUBE
AND
POTTER MODEL 6-424 GLMD-5
FLOWMETERS
(Under Contract No. F8-51390)

By
Fred Videon
and
G. L. Smith

Conducted for
The Martin Company, Denver Division, Denver, Colorado
Through
Colorado State University Research Foundation
Civil Engineering Section
Fort Collins, Colorado
June 1958

CER 59 FV 11

EVALUATION OF THE PERFORMANCE OF
THE GULTON ULTRASONIC, GENTILE TUBE
AND
POTTER MODEL 6-424 GLMD-5
FLOWMETERS
(Under Contract No. F8-51390)

By
Fred Videon
and
G. L. Smith

Conducted for
The Martin Company, Denver Division, Denver, Colorado
Through
Colorado State University Research Foundation
Civil Engineering Section
Fort Collins, Colorado
June 1958

CER 59 FV 11



U18401 0591647

ABSTRACT

This report represents an investigation and evaluation of the performance of several types of flowmeters under simulated prototype conditions.

Three types of flowmeters were tested: Gulton Ultrasonic, Gentile Tube, and Potter Model No. 6-424 GLMD-5. The Gulton Ultrasonic Meter on the basis of initial test results was found to be of faulty design, and was, therefore, excluded from further testing.

Meter performance for changes in flow and fluid properties was studied. Changes in flow properties included both low and high back pressure intensities, and turbulence induced immediately upstream of the meter by means of a grid. Injection of air into the test line produced a change in the mass density of the fluid - - a fluid property. Meter sensitivity in recording discharge were also made using combinations of peizometric taps located at various positions along the boundary geometry.

A comparison is made of the performance of the flowmeters under similar changes in flow and fluid properties.

TABLE OF CONTENTS

<u>Chapter</u>		<u>Page</u>
	ABSTRACT	i
I.	INTRODUCTION	1
II.	EXPERIMENTAL EQUIPMENT	2
	A. Potter Meter	2
	B. Gentile Tube	3
III.	EXPERIMENTAL PROCEDURE	4
IV.	PRESENTATION AND DISCUSSION OF RESULTS	8
	A. Potter Meter	8
	B. Gentile Tube	9
V.	CONCLUSIONS FROM EXPERIMENTAL RESULTS	12

I. INTRODUCTION

The objectives of this report are the investigation and evaluation of the performance of three different flowmeters when subjected to the same changes in flow and fluid properties. The three flowmeters considered were the Gulton Ultrasonic, the Gentile Tube, and the Potter Model No. 6-424 GLMD-5.

Dr. Dahlke of Gulton Industries, Inc., tested the Gulton Ultrasonic Meter for two days, March 13 and 14, 1958, using the Colorado State University staff and equipment. On the basis of the test results it was concluded that changes in the meter design would be necessary for accurate flow determination. Consequently, this report considers only the performance of the Gentile Tube and Potter Model 6-424 GLMD-5, hereinafter called Potter Meter, flowmeters.

Basically, the meters were tested for the effect of various test conditions upon the rate of discharge. Those involving the simultaneous performance of both meters were:

1. The change in mass density of the metered fluid, and
2. The variation in pressure head throughout the system.

The Potter Meter was investigated for the influence on its performance of a turbulence grid in an upstream position relative to the meter.

The Gentile Tube was investigated for sensitivity of response to various combinations of piezometric head taps along the flow boundary. The taps were varied not only in elevation but also in the direction of flow.

II. EXPERIMENTAL EQUIPMENT

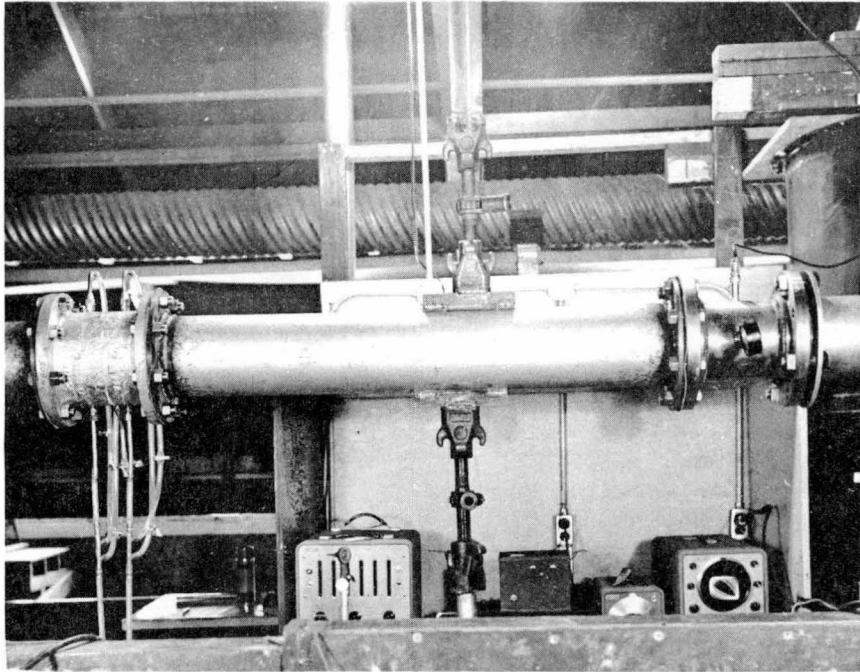


Fig. 1 - The Gentile Tube (left) and Potter Meter 6-424 No. GLMD-5 (right) as they appeared in the test section. The distance between meters is five feet with flow from left to right.

A. Potter Meter

The Potter Meter, Fig. 1, is a turbine type meter. The rotation of the rotor generates an A.C. (alternating current) wave, the frequency of which is a function of the speed of rotation, which is also a function of the velocity distribution immediately upstream of the meter. The calibration of this meter, illustrated in Fig. 2, is plotted in terms of rate of flow in gallons per minute versus frequency in cycles per second, Fig. 6.

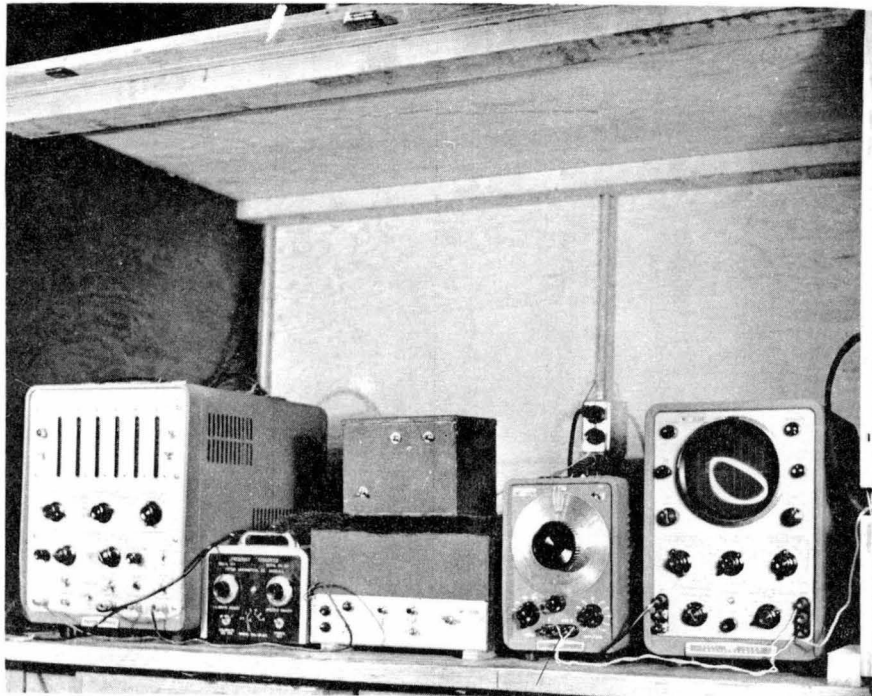


Fig. 2 - Instrumentation for determining flow rates as recorded by Potter Meter 6-424 No. GLMD-5. Left to right: electronic counter; frequency converter; timer (top); keyboard and relays which control and synchronize the timer, the counter and discharge into the calibration tank; oscillator, and oscilloscope.

B. Gentile Tube

The Gentile Tube is a pressure type meter. Its operation is dependent upon the differential in pressure intensity, which is measured by means of piezometric head taps, Fig. 3, located along the flow boundary upstream and downstream of the meter. The tap upstream of the meter constriction records the total energy head - - the velocity head plus the static head. The downstream tap records nearly the same static head minus part of a velocity head. The Gentile Tube is also equipped with a center tap which records the static pressure at the meter throat. The difference in static pressure in feet of water was determined by means of a differential manometer, Fig. 4. The calibration of this meter is in terms of the rate of flow in gallons per minute versus inches of water, Fig. 9.

III. EXPERIMENTAL PROCEDURE

The meters were tested in series in the test section with the Gentile Tube five feet upstream from the Potter Meter. Tests were run simultaneously on the meters whenever possible.

In testing the meters, water was discharged into a calibration tank for a given period of time. During this period the pulses from the Potter Meter were counted by an electronic counter. Simultaneous with the pulses count, several manometer readings to the nearest 0.005 foot were made.

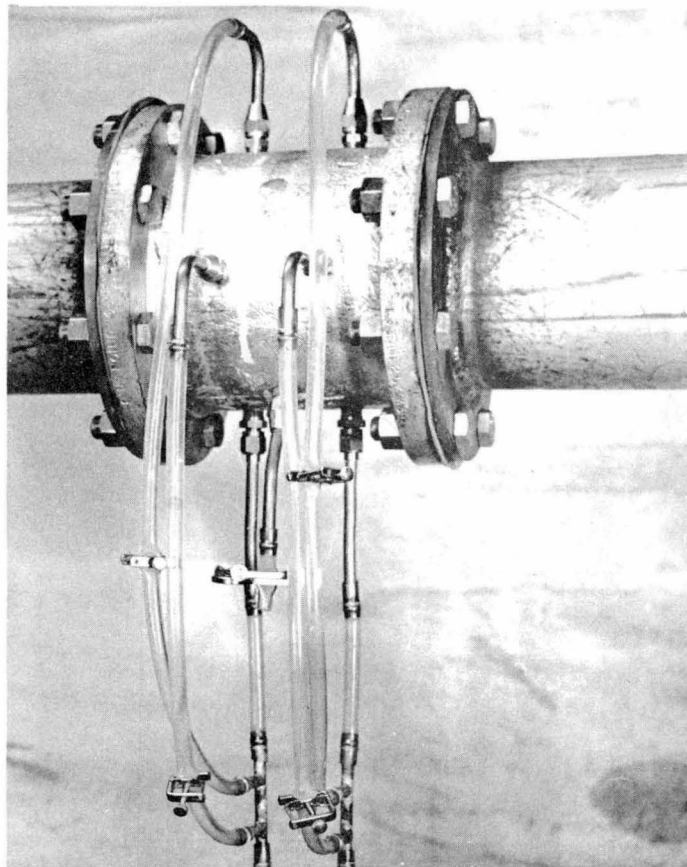


Fig. 3 - Gentile Tube showing pressure tap locations. All taps may be operated simultaneously as a unit or individually. The plastic tubing connecting pressure taps and manometer (Fig. 4) permitted visual control of air bubbles.

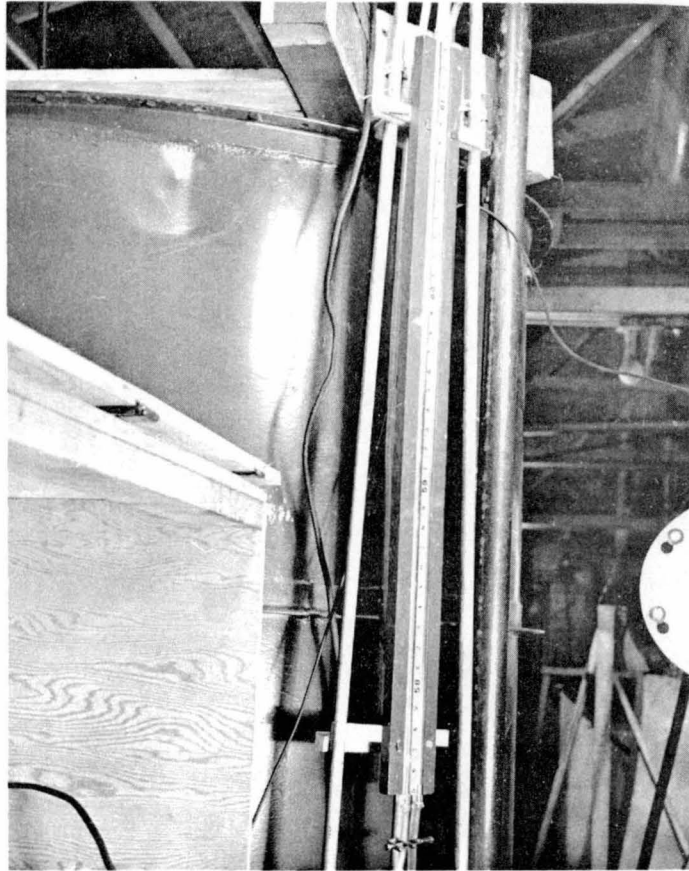


Fig. 4 - Differential water manometer used to record static pressure differential in Gentile Tube. Readings were ~~to~~ to five-thousandths of a foot.

The quantity of water discharged was equal to the volume of water per unit of time -- ft^3/sec . The rate or flow -- cubic feet per second -- was then converted to gallons per minute. The frequency output from the Potter Meter was equal to total pulse count divided by the total time in seconds.

The testing schedule given in Table I was followed in the evaluation of the meters.

TABLE I. Test Schedule for Evaluation of Flowmeters

Test No.	Type of Experiment	
	Gentile Tube Meter	Potter Meter
1	Low back pressure calibration	Low back pressure calibration
2	High back pressure calibration	High back pressure calibration
3	Mass density calibration -- air introduced into line at pressures of 10, 20, and 80 psig.	Mass density calibration -- air introduced into line at pressures of 10, 20, and 80 psig.
4	Low back pressure of calibration using various combinations of piezometric head taps	
5	Calibration using only upstream and center piezometric head taps	
6		Calibration with a turbulence grid upstream

The procedure used in following the test schedule of Table I is summarized as follows:

1. Test 1 was a 12 point calibration. Six points were taken in tests 2, 4, 5, and 6. Ten points were taken in test 3.
2. Tests 1 and 2 are self-explanatory. In test 3 air was injected into the line through a 1/4-inch diameter hole. A constant volume of air inflow was maintained by the pressure regulator, (Fig. 5), which held the air pressure at the point of injection to approximately 5 psig.
3. Tests 4 and 5 were made to determine the extent, if any, of variation in the piezometric head differential for different combinations of taps - - boundary orifices - - when the discharge through the Gentile Tube was constant. The effect of individual taps as well as of taps in combination were investigated.

4. In test 6 a turbulence grid constructed of 1/2-inch steel bars placed 1-inch center to center was inserted in the line immediately upstream of the Potter Meter. This was to determine what effect, if any, the turbulence field produced by the grid might have on the meter performance.

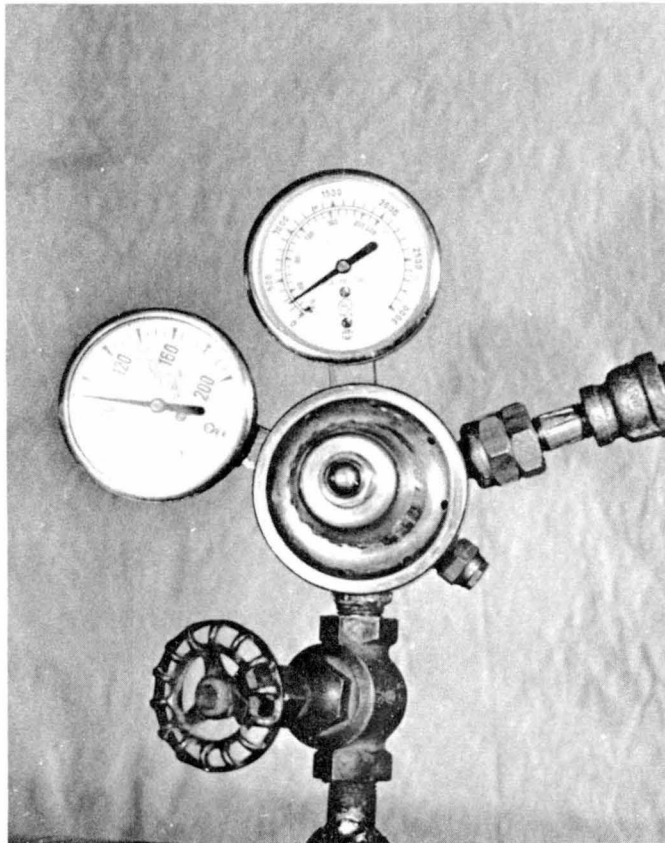


Fig. 5 - Pressure regulator for control of air injection into the test line. Location of regulator was six feet upstream of the Gentile Tube.

IV. PRESENTATION AND DISCUSSION OF RESULTS

A. Potter Meter: Model 6-424 GLMD-5

The evaluation of the performance of the Potter Meter is based on (a) the effect of change in pressure intensity and mass density of the fluid upon the meter calibration, and (b) the effect of fluid turbulence upon the meter calibration. Experimental results of the effect of a variation in either fluid or flow properties upon the meter calibration -- change in cycles per gallon (CPG) output--are given in Table II.

Table II. Effect of Change in Fluid and Flow
Properties Upon the Potter Meter
Calibration

Test No.	Type of Test	Average CPG	Diff. From Test No. I.	Percent Dev. from Test No. I.
1	Low back pressure calibration	12.182	0	0
2	High back pressure calibration	12.205	0.023	0.19
3	Air injection-10 psi	13.405	1.223	10.00
	Air injection-20 psi	15.045	2.863	23.50
	Air injection-80 psi	16.940	4.758	39.10
6	Turbulence grid upstream	12.270	0.088	0.72

A description of each test result of Table II is as follows:

1. Variation of the pressure head within the system has little effect upon the performance or accuracy of the flowmeter (Fig. 6).
2. The change in mass density of a fluid will produce large errors in meter calibration. Fig. 7 illustrates the effect of a change in mass density upon the performance of the flowmeter. From the figure the following is evident:
 - a. At high discharges the influence of a small change in mass density is not significant.

- b. For the range of discharges tested a small change in mass density will adversely affect the flow characteristics within the meter, that is, a highly unstable condition within the meter will develop at low discharges.
 - c. Decreasing the mass density of an incompressible fluid by mixing with a compressible fluid will decrease the performance efficiency of a flowmeter.
3. Because of the proximity of the turbulence grid to the meter, the meter, in general, would be in a region of large-scale velocity or pressure nonuniformities. The effectiveness of the straightening vanes, an integral part of the meter, on minimizing the induced turbulence is shown in Fig. 8. Therefore, on basis of the figure, turbulence will not affect the meter performance.

It was noted that during the high pressure calibrations the rated flow gradually increased. This was attributed to the possible influence on the flow properties of the hydraulic valve located downstream from the meters.

B. Gentile Tube

The evaluation of the performance of the Gentile Tube is based on (a) the deviation of experimental data from the meter equation given by the meter manufacturer, (b) the effect of change in mass density of the fluid upon the meter calibration, and (c) the change in piezometric head--meter sensitivity--produced at constant discharge by various combinations of piezometric head taps located along the flow boundary of the meter.

The meter equation, as given by the manufacturer, is

$$Q = 190 (\Delta H)^{1/2} \quad (1)$$

in which Q is the discharge in gallons per minute, and Δh is the difference in piezometric head between two points on the flow boundary measured in inches of water. The curve of the theoretical equation is compared in Fig. 9 with experimental data obtained from meter calibration at high and low back pressures. The equation of the meter on the basis of experimental data is

$$Q = 180 (\Delta H)^{1/2} \quad (2)$$

Equation 2 simply states that the actual or measured discharge, on an average, will deviate 5.28 percent from the discharge computed by Equation 1.

Equation 1 differs from Equation 2 only in the coefficient, which is a function of those factors affecting the meter calibration, namely: (a) head loss through the flow system, and (b) the accuracy of measurement of discharge through the meter. Obviously, the head loss through one flow system will differ from that through another, which in itself would affect the coefficient. However, the precision of discharge measurement would have the greatest effect on the coefficient. Thus, the meter coefficient will be highly sensitive not only to any flow or fluid properties which affect the meter performance, but also to the methods used in its calibration.

Similar to test results of the Potter Meter, a change in mass density of the fluid produced large errors in the calibration. Contrary, however, to the performance of the Potter Meter, the Gentile Tube, for small changes in fluid density, showed a greater loss in performance efficiency. This can be seen in Fig. 10, which shows a marked decrease in efficiency with each decrease in the fluid density.

In testing for sensitivity of meter performance by use of various combinations of piezometric head taps along the meter flow boundary, it

was found that the side tap would give the least error in discharge measurements. Fig. 11 shows that the top and bottom taps used in combination will give the greatest error in discharge measurements. It was noted during the experiment that the top tap when used alone permitted the intrusion of air into the manometer tubes causing a false reading of the pressure differential across the meter.

A greater error in discharge measurement occurred when the upstream and center piezometric rather than the upstream and downstream taps were used. The reason for the increase in error was due probably to the adverse flow conditions developed at the position of the center tap. Since the flow converged at this point, separation from the boundary could occur unless the streamlines of the flow conformed identically with the flow boundary. Separation would produce piezometric head readings less than the true piezometric head of the flow. Thus, for the same discharge, readings of the piezometric head in regions of more uniform flow condition--upstream and downstream--would be more accurate than those taken in regions of nonuniform flow--upstream and center.

V. CONCLUSIONS FROM EXPERIMENTAL RESULTS

1. The Potter Meter is more accurate than the Gentile Tube. However, it cannot produce the desired one-half percent accuracy under all test conditions. Its accuracy increases if it is operated at high discharges.
2. The Gentile Tube will measure flow with deviations of two or three percent at the high discharges if great care is exercised in determining Δh .
3. Neither meter will operate satisfactorily in measuring liquid flow rates when bubbles of gas are mixed with the liquid which may enter the line either from a leak, boil-off, or as a result of cavitation.

KEUFFEL & ESSER CO. MADE IN U.S.A.
3 X 3 CYCLES

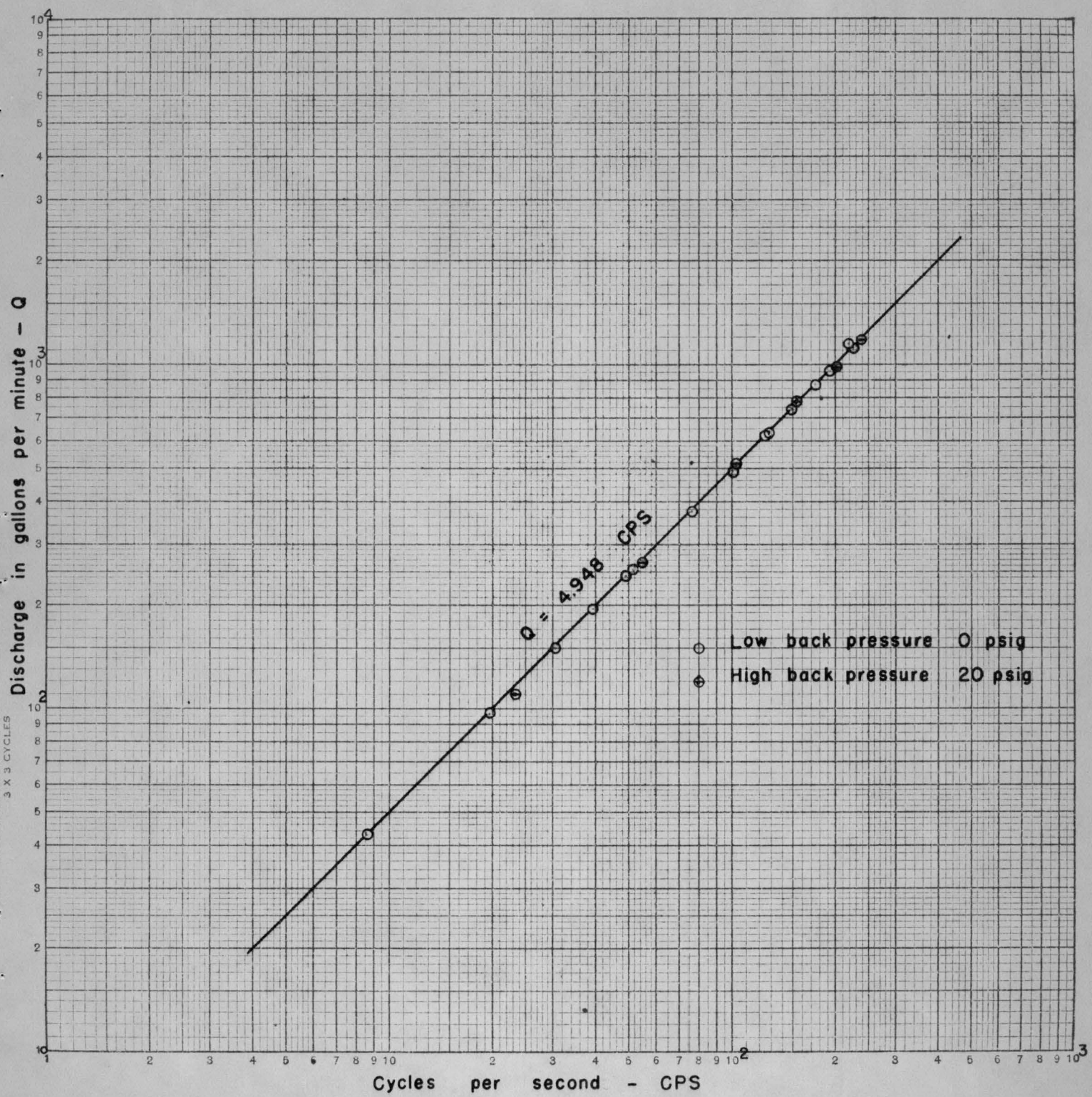


Fig. 6 Performance characteristics of a Potter Meter : Model No. 6-424 GLMD-5 at low and high back pressures

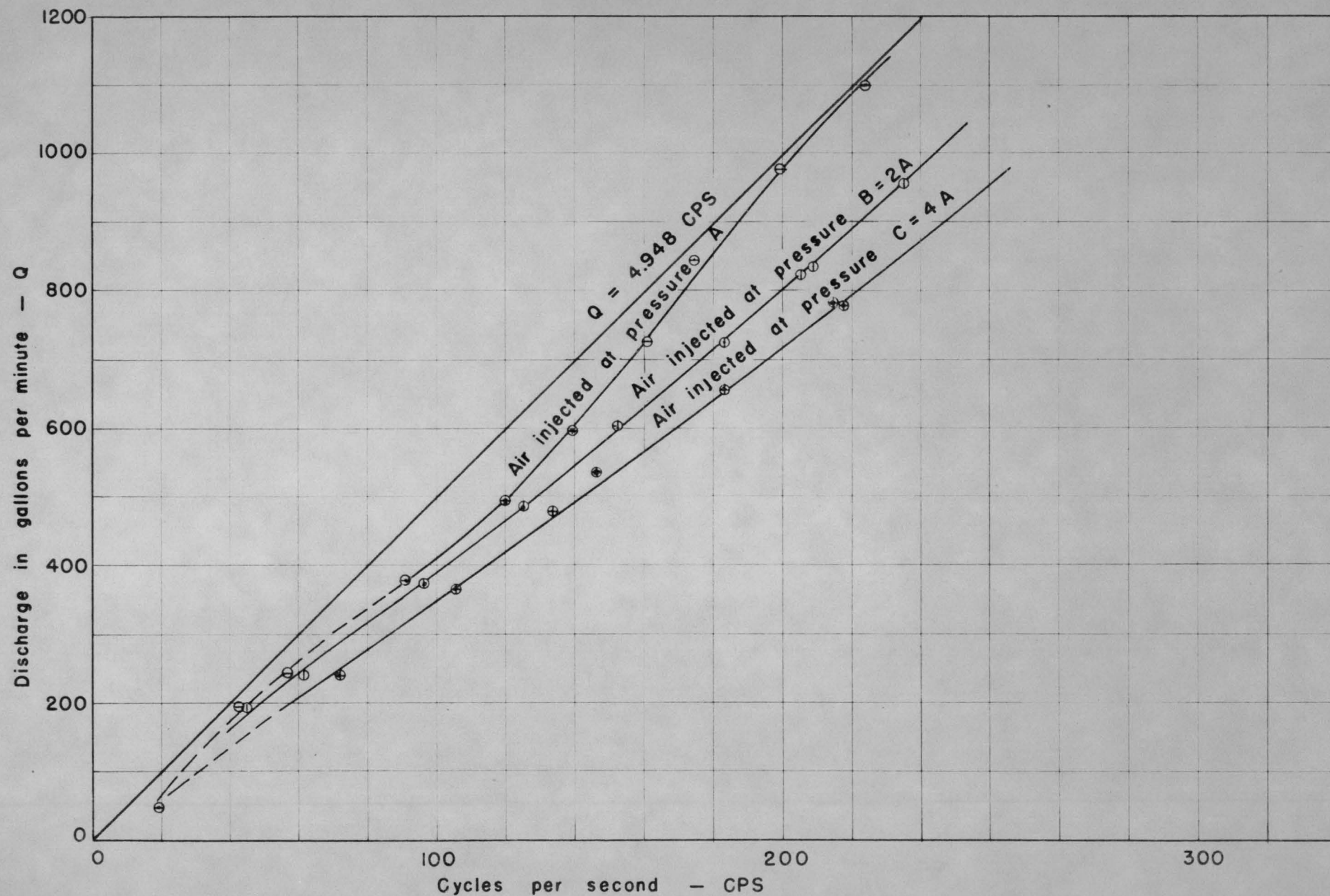


Fig. 7 Performance characteristics of a Potter Meter: Model No. 6-424 GLMD-5 for a change in mass density of the metered fluid

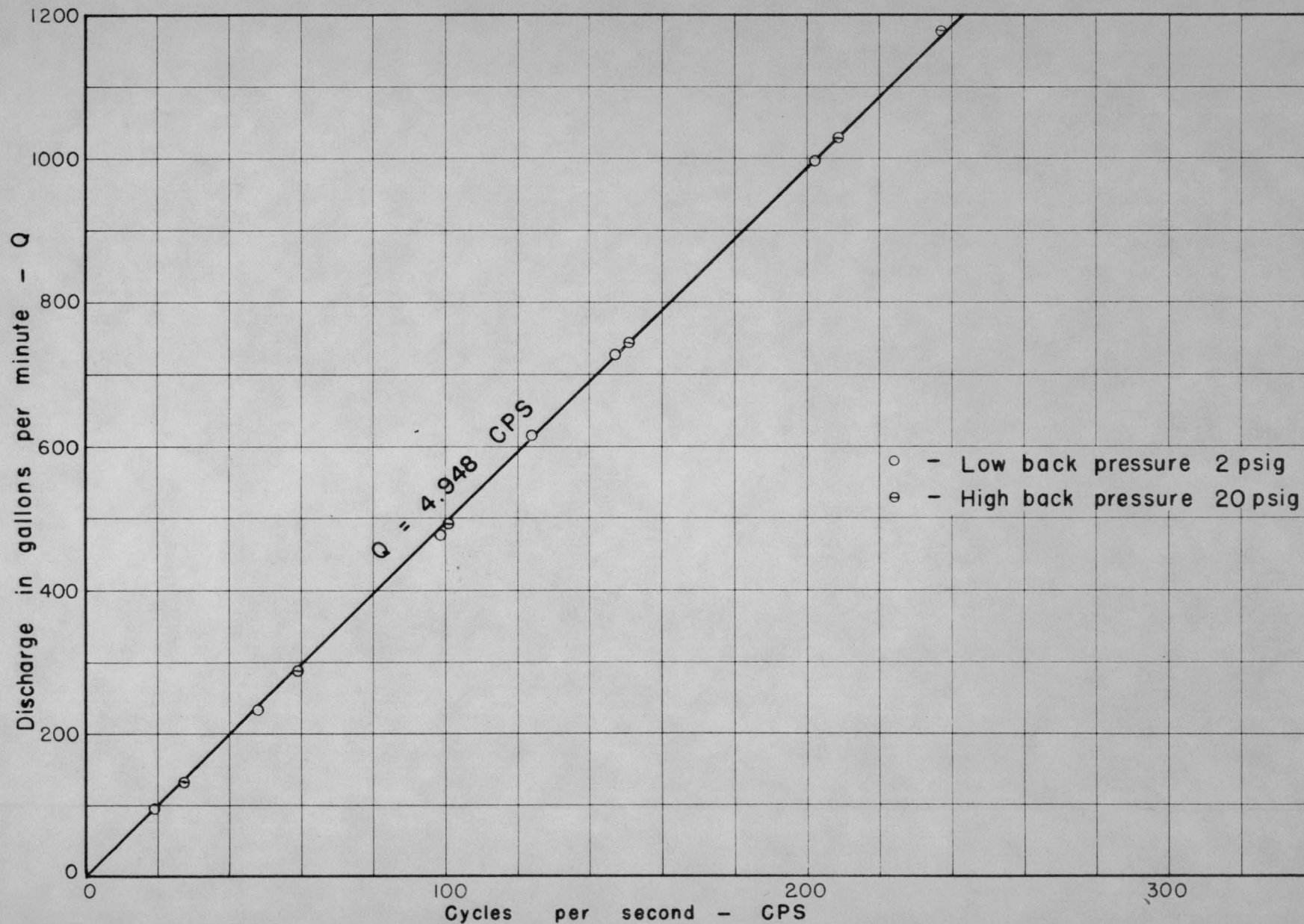


Fig 8 Influence of turbulence on the performance characteristics of a Potter. Meter : Model No. 424 GLMD - 5

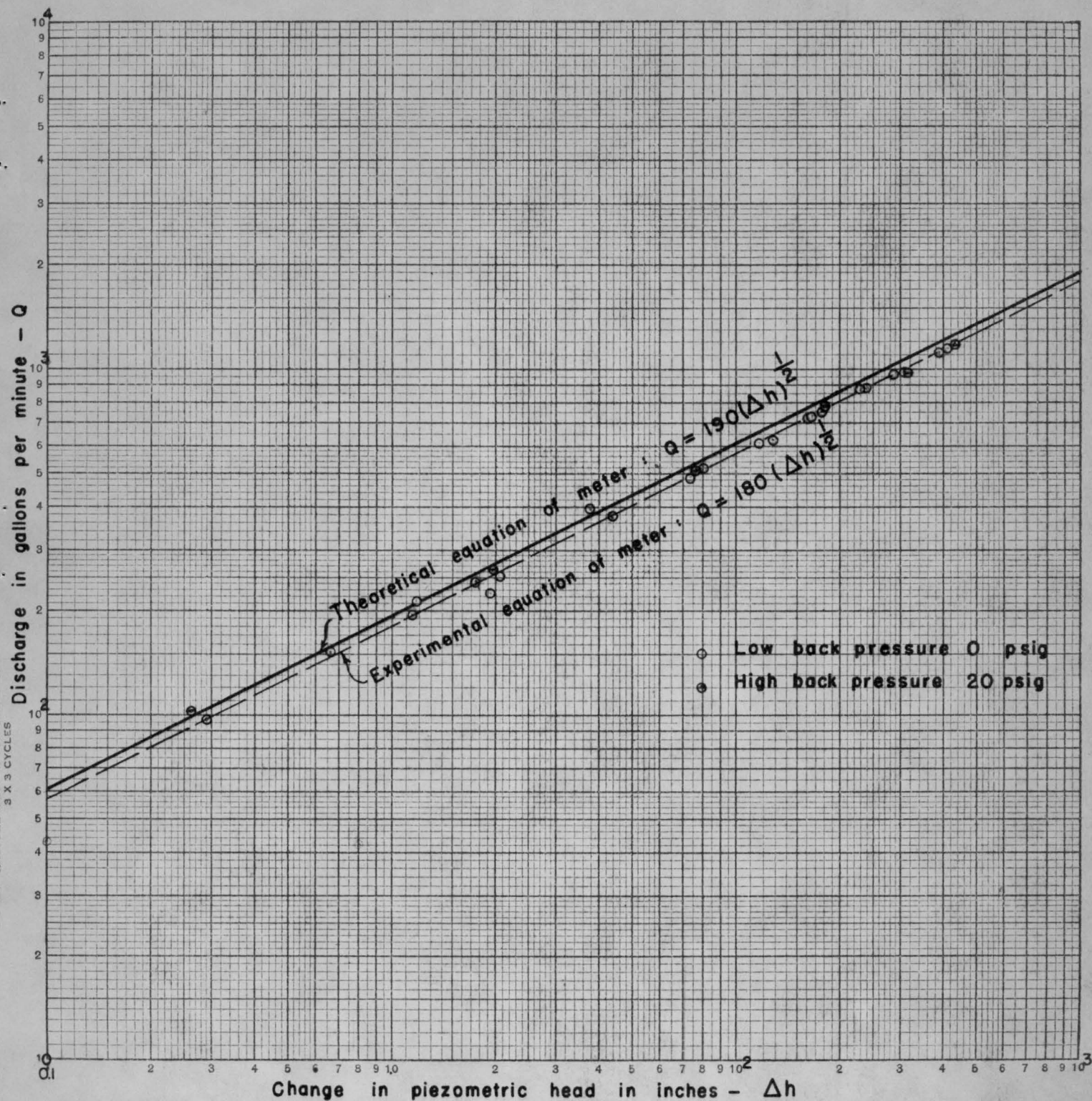


Fig. 9 Performance characteristics of a Gentile Tube Flowmeter at low and high back pressures

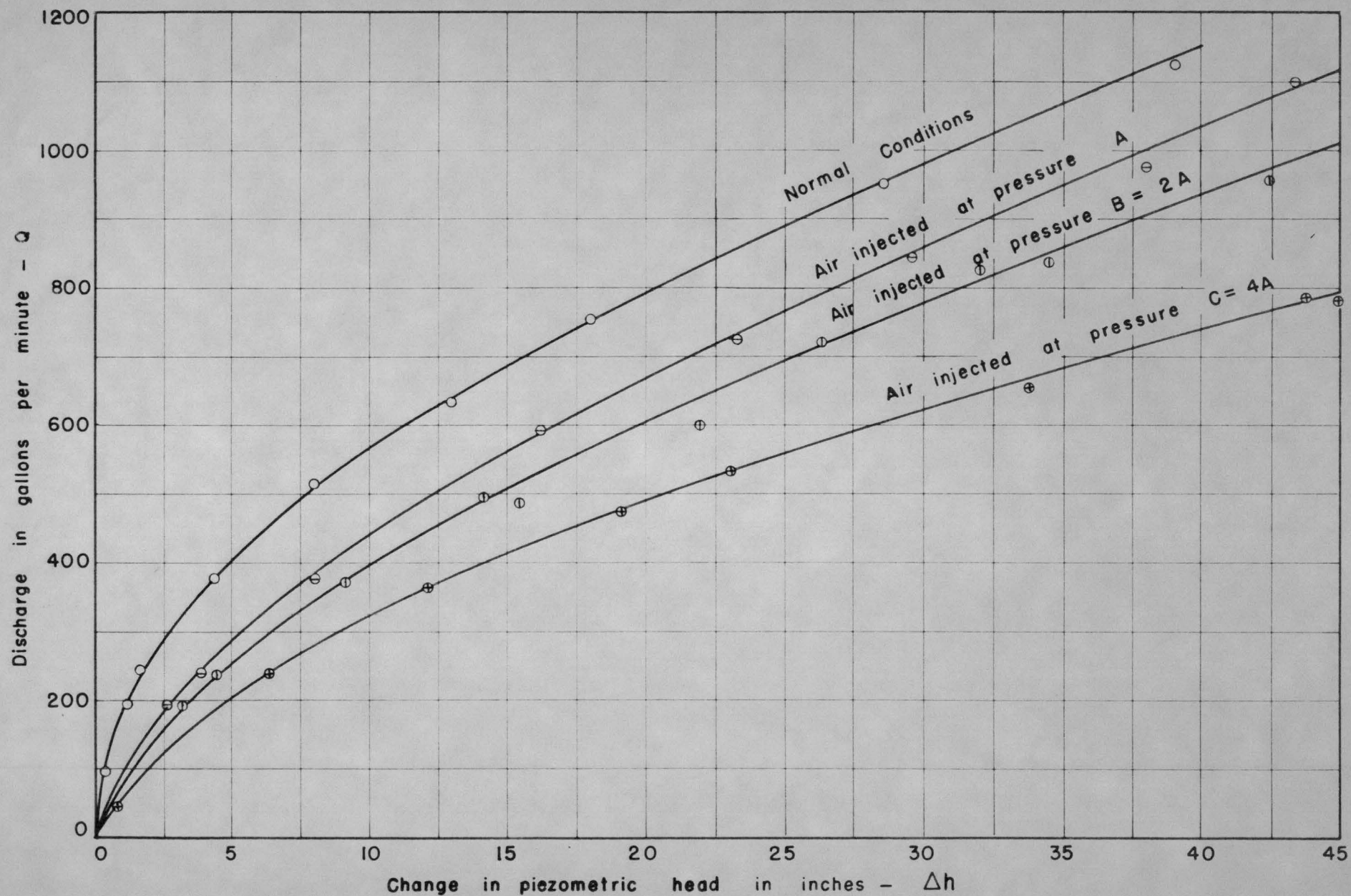


Fig. 10 Performance characteristics of a Gentile Tube for a change in mass density of metered fluid

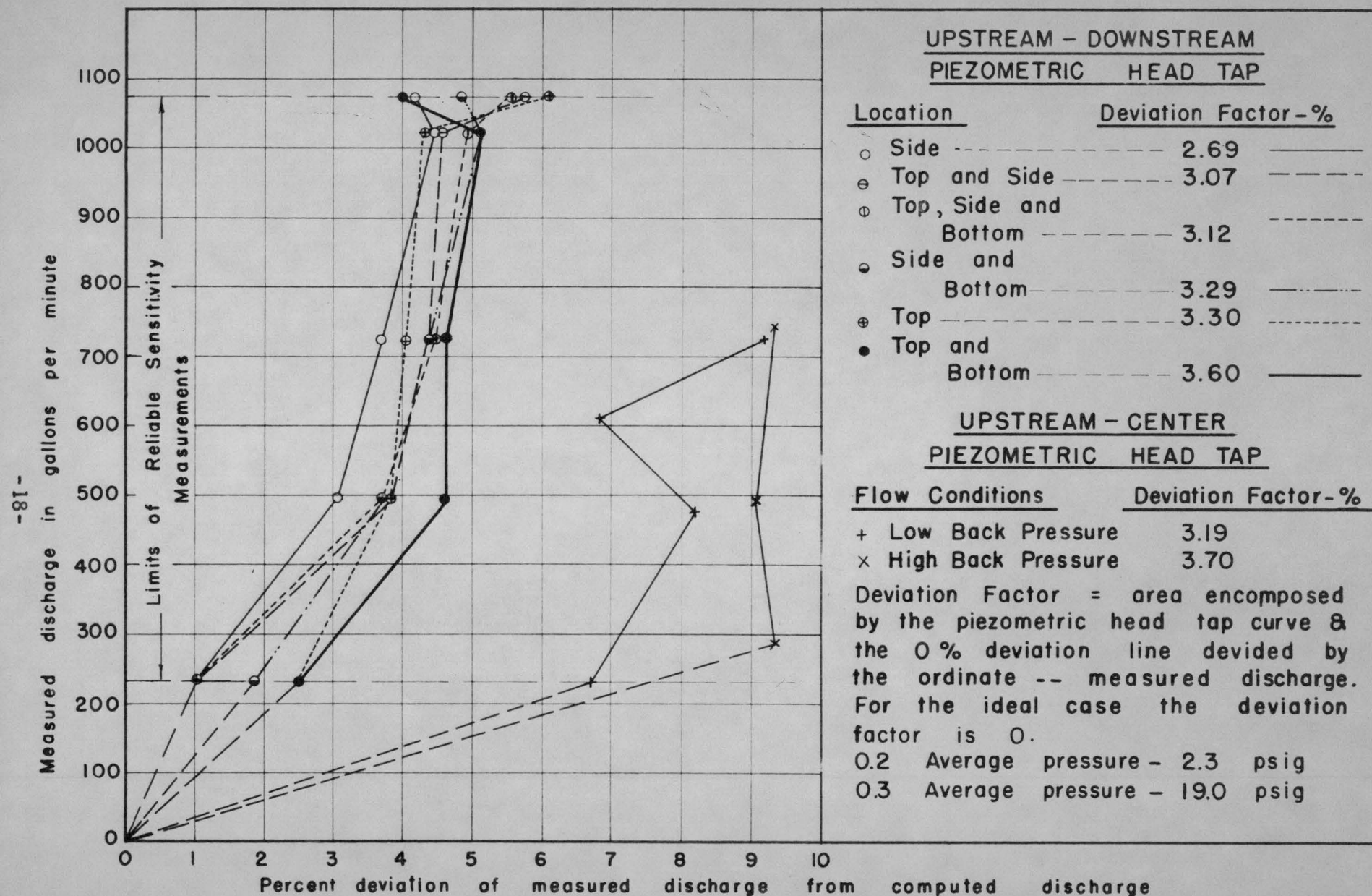


Fig. II Influence of piezometric head tap location on the performance characteristics of a Gentile Tube flowmeter